

Improving Nuclear Reactor Safety: The Melt Coolability and Concrete Interaction Program

Challenge

Nuclear plants similar to the one shown in Figure 1 operate safely throughout the world. The probability of a core melt accident is extremely low, but it is important to demonstrate plant safety in the event of such very low-probability occurrences. Nuclear regulatory agencies throughout the world seek improved approaches to melt coolability and core-concrete interaction that can be incorporated into existing and future nuclear reactor designs.

Argonne's Answer

Scientists at Argonne National Laboratory are spearheading a collaborative effort to address resolution

of safety issues related to severe accidents at nuclear power plants. Other participants (along with the U.S. Department of Energy) include the U.S. Nuclear Regulatory Commission and the 12 countries (listed under Collaborators), which are being represented by the Nuclear Energy Agency of the Organization for Economic Cooperation and Development. Goals of the project are to:

- Devise improved guidelines for managing low-probability severe accidents in existing nuclear plants, and
- Provide data to support development of improved containment designs for future nuclear plants.



Figure 1. Nuclear plants operate safely throughout the world, but they could potentially be safer. Argonne researchers are participating in a collaborative worldwide effort to identify new designs and safety strategies for such plants. (Photo courtesy of Southern California Edison.)

During the project, researchers will examine issues surrounding the extremely unlikely scenario in which a nuclear reactor core cannot be cooled sufficiently to prevent fuel melting. This event can occur after the fission reaction has been shut down, because decay heat remains in the fuel. In this case, the core melt can cause failure of the reactor pressure vessel and release of molten debris to the reactor containment building. When this happens, the molten debris must be cooled through some emergency intervention to prevent a failure of the reactor containment building. Current theory suggests that the debris can be cooled by water flooding from above. Before such strategies can be implemented, however, scientists must have a clearer understanding of all the interactions and ramifications of such cooling interventions.

Approach

The Melt Coolability and Concrete Interaction (MCCI) program, which began in 2002 and is scheduled to continue through 2006, will focus on conducting reactor material experiments and associated analysis to meet two technical objectives.

Objective One is to resolve issues concerning the cooling of debris outside of the reactor containment vessel, using both confirming evidence and test data for cooling mechanisms identified in earlier Argonne tests.

Objective Two is to address uncertainties surrounding the interactions that occur when molten core erodes through concrete under wet- and dry-cavity conditions.

In the first year, work will commence on small-scale water ingress and crust strength (SSWICS) testing to obtain data on water ingress cooling mechanisms. Researchers will also perform initial analysis and design activities for long-term, two-dimensional core-concrete interaction tests that are scheduled to begin in 2003. The SSWICS test setup is shown in Figure 2.



Figure 2. Photograph showing the configuration for the small-scale water ingress and crust strength test system.

SSWICS testing addresses the ability of water to enter cracks and fissures in reactor debris, an issue that is of concern in several accident scenarios. In particular, testing will focus on the composition of melted core materials and on the effect of system pressure on water entry rate.

Impact

Results of the MCCI program will be used to support development of accident management guidelines for existing and future advanced nuclear plant designs.

Collaborators

Nuclear Energy Agency of the Organization for Economic Cooperation and Development, representing:

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|---------------------|--------------------------------------|
| • Belgium | • Norway |
| • Czech Republic | • Spain |
| • Finland | • Sweden |
| • France | • Switzerland |
| • Germany | • United States |
| • Hungary | • U.S. Department of Energy |
| • Japan | • U.S. Nuclear Regulatory Commission |
| • Republic of Korea | |

Sponsor

U.S. Nuclear Regulatory Commission

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